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ABSTRACT

The purpose of this study was to determine whether different types of practice strategies are equally effective in facilitating encoding strategies and in subsequent information acquisition and retrieval by students identified as possessing high, medium, and low prior knowledge levels in a content area. Within the context of the encoding-specificity principle, the effectiveness of verbal and visual testing of information acquired from visually complemented instruction was also investigated. Subjects, who were 240 graduate and undergraduate students, were randomly assigned to eight treatment groups which determined the level of practice received and the testing mode (verbal or visual). Each student received a pretest, participated in the instructional presentation, and then received a battery of tests designed to measure various educational objectives. Results indicated that practice strategies: (1) can be effective instructional variables in improving student achievement; (2) function differentially in promoting student achievement of different educational objectives; and (3) can function to reduce differences among students possessing different levels of prior knowledge. Additionally, it was found that visual tests appear to be more effective than verbal tests in assessing information communicated by visualized instruction. Supplemental materials include sample test questions, statistical data, and 54 references. (MES)

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# THE EFFECT OF VARIED PRACTICE ACTIVITIES IN COMPLEMENTING VISUALIZED INSTRUCTION

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## Abstract

The concept of individual differences has become an important instructional variable. Considerable research and theory exist which contend that if provided the right environmental conditions (practice) almost every student can be expected to achieve almost any objective. The purposes of this study were to determine: (a) whether different types of practice strategies are equally effective in facilitating the achievement of students identified as possessing high, medium and low prior knowledge levels in a content area, and (b) whether verbal and visual tests are equally effective in measuring student achievement--when the instructional content they receive is complemented by visualization. Two hundred forty students were randomly assigned to one of eight treatment groups, received a pretest, participated in their respective instructional presentation, and received a battery of tests designed to measure different educational objectives. Results indicated that practice strategies: (a) can be effective instructional variables in improving students achievement, (b) function differentially in promoting students' achievement of different educational objectives, and (c) can function to reduce differences among students possessing different levels of prior knowledge (high, medium, low). Additionally, it was found that verbal and visual tests do not appear to be equally effective in assessing information communicated by visualized instruction.

## Introduction

It is doubtful whether any instructional theory will ever be developed which would universally and uniformly prescribe optimum learning environments for all students. However, instructional designers are constantly attempting to identify effective strategies for managing the learning environment to maximize student achievement. This goal has been difficult to achieve since learners possess a multiplicity of cognitive, affective, and physiological variables. Considerable research conducted in this area, utilizing various types of learners, has found that visualization of instruction, mathemagenic activities, elaborations, and generally all types of practice activities have the potential for improving students' information acquisition, storage and retrieval (Dwyer, 1978; Rothkopf, 1970; Aronson & Briggs, 1983; Gropper, 1983; Reigeluth, 1983). It is assumed that these practice variables facilitate students' encoding strategies by providing opportunities for identifying and restructuring critical information components so that new links and associations can be established.

Early research and literature in the area of manipulating learning environments (Carroll, 1963; Bruner, 1966; Bloom, 1968) contended that if the instructional environment was properly prepared and managed any student would be capable of achieving any objective. From this perspective evolved the aptitude-by-treatment orientation (Bracht, 1970; Rhetts, 1974; Cronbach & Snow, 1977) which posited that differentially designed instructional treatments would be more or less effective in promoting increased levels of achievement for different levels of students and that specifically designed instructional treatments, for specific types of learners, would function to maximize their achievement.

Closely aligned with the concept of practice activities facilitating encoding processes, Tulving and Thomson (1973) have proposed the encoding specificity principle — that memory is better if the cues used in the original instructional/acquisition environment are used in the testing/retrieval environments. Similarly, Nitsch (1977) and Battig (1979), in adhering to the encoding specificity principle, have indicated that any change in the retrieval environment from that which occurred in the original learning environment produces marked decrements in student performance.

## Problem Statement

The purpose of this study was to investigate the effectiveness of different types of practice activity in facilitating encoding strategies and subsequent information acquisition and retrieval by students possessing different levels of prior knowledge (high, medium, low) in a content area. Within the context of the encoding-specificity principle, the effectiveness of verbal versus visual testing of information acquired from visually complemented instruction was also investigated. Additionally, the instructional effectiveness of both overt and covert practice activity was examined.

Specifically, the purposes of this study were to determine: (a) whether different types of practice strategies are equally effective in facilitating the achievement of students identified as possessing high, medium, and low prior knowledge levels in a content area -- or whether some types of practice activities are more effective for students at specific prior knowledge entry levels; (b) whether different types of practice activities function differentially in facilitating the achievement of students in the high, medium and low prior knowledge levels on identical objectives -- or whether some practice activities are more effective for students at specific knowledge levels and for specific types of educational objectives; and (c) whether verbal and visual tests are equally effective in measuring students' achievement of different educational objectives when students possessing different prior knowledge levels receive different practice activities --when the instructional content they receive is complemented by visualization.

## Literature Review

Cognitive theory contends that when students interact with selected stimuli, they do more than merely respond to the stimuli; they relate new stimuli to existing knowledge and make combinations, inferences, abstractions, and new relationships. Through this reciprocal interplay of assimilation and accommodation, students can develop new skills and schemata that they did not possess. When this process occurs the information is said to have been encoded. Stimulating students to encode new information is not an easy task since there is a tendency for them to skip over content for which they have no immediate need or adequate referent (Doran & Holland, 1971). Practice activity allows the necessary time for both mental and physical interaction to occur and for incoming information to be held in short-term memory long enough to be elaborated upon and encoded for long-term memory (Anderson, 1980; Murray &

Mosberg, 1982). Lindsay and Norman (1972) have argued that the longer an item is maintained in short-term memory by rehearsal (practice) the greater the probability that it will be transmitted into long-term memory and be retained. Pursuing this line of reasoning, it would follow that the longer and more intense type of practice activities would provide the students with greater amounts of time to interact with the intricacies of the content and thereby provide greater opportunity for them to acquire the designated relationship. Related to this issue Travers (1970, p. 131) has stated ". . . attention coupled with activities involving the utilization of information are likely to be much more successful."

Practice activities exist on a continuum, each differing in the intensity of student involvement required and, thus, each type of practice may have differential effects on specific learning outcomes. If this is the case, then it may also follow that practice intensity is related to the level of learning to be accomplished -- the more complex learning requiring the more intense or involved type of practice activity. For example, covert practice (reading summary statements, reading questions and answering them mentally) generally requires less mental activity and less time than does overt practice in which the overt activity ensures that adequate time is spent interacting and encoding the information. Writing answers to questions, notetaking, and drawing diagrams may be considered to be examples of overt practice. In this respect, overt practice which requires that the learner actively work with the designated content to generate knowledge and/or produce an answer also encourages the learner to become aware of his deficiencies and provides opportunities for remediation (Bransford, Franks, Morris, and Stein, 1979). Consequently, overt practice is more likely to result in an elaborative level of processing which in turn provides the type of memory structures which facilitate both retention and retrieval. Craik and Tulving (1975), in commenting on the information-retrieval issue, have indicated that the type of rehearsal (practice) activity employed by students in interacting with the content material has many implications for the level at which information is processed and the type of information which can later be retrieved.

Justification for the use of visual test items to evaluate students' learning from visualized instruction has its generic roots in a number of hypotheses and theories (Carpenter, 1953, sign-similarity hypotheses; Hartman, 1961, stimulus generalization theory; Severin, 1967, cue summation theory; Tulving & Thomson, 1973, encoding specificity principle; Morris, Bransford and Franks, 1977, transfer-appropriate processing principle). Dwyer (1978), in reviewing the results of more than 650 articles related to the effective use of visualization in the learning process, concluded that words and pictures are not processed in the same way or are they equally effective in facilitating student achievement of different educational objectives. A number of researchers (Paivio, 1971; Nelson, et al., 1974; Jacoby, 1974; Craik & Tulving, 1975; Tulving, 1976) support this contention and have attributed the effectiveness of visualization in the learning process to the fact that visualization can be processed simultaneously on several levels. Paivio, Rogers and Smythe (1968) have suggested the possible existence of dual encoding and retrieval systems,

each functioning as a separate entity with the capability to work in unison with each other. Basically, this orientation (Paivio, et al., 1968; Paivio, 1971) proposes a model involving two independent memory systems: one having the capability of processing verbal symbols, the other having the capability of processing visual information. In essence, the dual-code theory claims that information is stored in long-term memory in terms of visual images and verbal representations (Anderson, 1980). Depending on the nature (form) of the information to be retrieved, action with the specific memory system would be initiated. A number of research studies have been conducted which may be interpreted as being supportive of the dual encoding and retrieval systems (Bahrick & Boucher, 1968; Paivio & Csapo, 1969; Bahrick & Bahrick, 1971; Cermak, 1971; Ternes & Yuille, 1972; Levie & Levie, 1975).

Probably the oldest and least controversial fact that can be derived from the research on human learning is that any change in the retrieval (evaluation) environment from that which occurred in the original learning environment produces marked decrements in learner performance (Nitsch, 1977; Battig, 1979). In this regard Lindsay and Norman (1977, p. 337) have stated that in the teaching learning environment, "the problem in learning new information is not in getting the information into memory; it is making sure that it will be found later when it is needed." Consequently, information retention level is assumed to be a direct function of the encoding occurring at the presentation stage and the degree to which the retrieval environment recapitulates this encoding (Battig, 1979; Tulving, 1979). The implications of this position would imply that in instructional situations where visualization was utilized in the encoding process and was not used in the retrieval (decoding) process, learner performance measures would yield gross underestimates, if not distortions, with respect to what and how much information had been originally acquired. This conceptualization suggests that information retrieval is a very specific process, easily disrupted. Since the features of the original learning cues are processed during a test, any reduction in the individual distinctiveness of the cues themselves should produce concomitant reduction in recall (Nelson, 1979).

Optimum validity in assessment of learner information acquisition apparently can only be obtained if there is a high degree of congruency between the presentation (encoding) mode and the retrieval (evaluation) mode; e.g., if visualization is an integral component in facilitating learner encoding of the information, then visualization should also be used in the test items (decoding phase) used to assess learner achievement. Tulving and Thomson (1973, p. 359) have stated that, "only that can be retrieved that has been stored, and how it can be retrieved depends ultimately on how it was stored." Research by Thomson and Tulving (1970), Winograd and Conn (1971), Thomson (1972), Kolers (1973), Tulving and Thomson (1973), Tulving (1976), Battig (1979) and Jacoby and Craik (1979) can be cited in support of this position.

## Materials and Procedure

The instructional content and evaluation materials used in this study were originally developed by Dwyer (1972), revised by Lamberski (1980), and further revised by the investigator. The instructional content which focused on the human heart, its parts, and functions contained approximately 1,800 words, and utilized 19 visuals of the heart. It was selected for use in this study because it permitted the evaluation of several different types of educational objectives directly generalizable to the classroom. Positioning of the visualization within the instructional script was determined by item analysis; visualization was placed where students had experienced difficulty in acquiring from the verbal instruction alone the information necessary to achieve on the criterion tests. Validity between the content and the criterion tests had been established by Dwyer (1972) and Dwyer and De Melo (1984).

## Criterion Measures

Each student in each treatment received a 36-item physiology pretest (Dwyer, 1972) and participated in one of the instructional presentations, followed immediately by a drawing test. Each student then took three separate 20-item multiple-choice criterion tests, either in the verbal format or visual format. Scores on these three individual criterion tests (identification, terminology, and comprehension) were combined into a 60-item composite test score. The verbal format of each of the 60 multiple-choice items consisted of a typical verbal stem and verbal response options. In designing the visual test items for each criterion test, the visual tests developed by De Melo (1980) were revised by the investigator so that the final version utilized only one drawing with four or five letter labels in all items in which it was possible to do so while maintaining clarity and correspondence to the verbal test items (see Figure 1). However, two items in the terminology test and all items on the comprehension test required four drawings. The item stems of both the verbal and visual test questions were verbal and asked the same question. In addition, the visual distractors in the visual tests corresponded to the verbal distractors in the verbal tests as closely as was reasonable. The following description of the criterion tests (Dwyer, 1978) illustrates the kinds of educational objectives assessed in this study.

Figure 1 About Here

**Drawing Test.** The objective of the drawing test was to evaluate students' ability to construct and/or reproduce items in their appropriate context. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents.

Identification Test (Verbal and Visual Format). The objective of the identification test was to evaluate students' ability to identify parts or positions of an object. This test required students to identify the numbered parts on a detailed drawing of a heart. The objective of this test was to measure the ability of the student to use visual cues to discriminate one structure from another and to associate specific parts of the heart with their proper names.

Terminology Test (Verbal and Visual Format). This test was designed to measure knowledge of specific facts, terms, and definitions. The objectives measured by this type of test are appropriate to all content areas that have an understanding of the basic elements as a prerequisite to the learning of concepts, rules, and principles.

Comprehension Test (Verbal and Visual Format). Given the location of certain parts of the heart at a particular moment of its functioning, the students were asked to determine the position of other specified parts of the heart at the same time. This test required that the students have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The test was designed to measure a type of understanding in which the individual can use the information being received to explain some other phenomenon.

Total Test Score (Verbal and Visual Format). The items contained in three of the four individual criterion tests (identification, terminology, and comprehension) were combined into a 60-item total test score. The purpose was to measure total achievement of the varied levels of objectives presented in the instructional unit.

## Treatments and Procedure

Four basic treatments representing different levels of practice were employed in this study. Students receiving each treatment received the same instructional script, visuals, terminology, and arrows. The four levels of practice are identified as levels of Factor A. Students receiving each of the four levels of Factor A were evaluated by either the visual or verbal test format making a total of eight experimental groups. Levels of Factor B referred to test format--Level 1 of Factor B being the verbal test format and Level 2 of Factor B being the visual test format.

Students receiving Level 1 of Factor A received no practice activity (See Figure 2, Plate 1). A practice activity was added to 18 of the 19 instructional pages for students receiving Levels 2, 3, and 4 of Factor A. Students in Level 2 of Factor A received summary statements at the end of each page that required a minimal amount of covert activity on the part of the students and did not review all the information in the instructional script. The summary statements were designed to provide the students with the opportunity for mental review of the instructional content. An example of an instructional frame received by students in Level 2 of Factor A is in Figure 2, Plate 2.

Level 3 of Factor A, represented by Figure 2, Plate 3, utilized a form of overt practice--fill-in statements immediately following each instructional page. These statements corresponded precisely to the summary statements in Level 2 of Factor A but had pertinent information omitted (one to six words). Participants were instructed to fill in the blanks, check answers at the top left of the next page, and, if incorrect, cross out the incorrect answer and write the correct answer above or to the left of the incorrect answer.

Level 4 of Factor A, represented by Figure 2, Plate 4, utilized a different form of overt practice which required that students shade with colored pencils the specified parts and functions of the heart. The parts and functions shaded corresponded to, as closely as possible, the words that were filled in the blanks in Level 3 of Factor A (see Figure 2, Plate 3. The colors used were selected to avoid a sense of color coding: black, green, yellow, and red. Red was used only in two circumstances in which four colors were required on a page; association of the red color with oxygen-rich blood was avoided.

Figure 2 About Here

Design and Analysis

Two hundred forty undergraduate and graduate students enrolled at The Pennsylvania State University participated in this study. Participants were randomly assigned to one of eight cells (N = 30) which determined both the level of practice they received and the testing mode (verbal or visual). Since one of the purposes of the study was to examine the influence that different practice strategies had on students possessing different prior knowledge levels in a content area, scores on the physiology pretest in each cell were arranged in descending order from top to bottom. The top ten scores in each cell represented the high prior knowledge level, the middle ten, the medium prior knowledge level, and the bottom ten, the low prior knowledge level.

The independent variables examined in this study were the levels of practice activity (levels of Factor A), testing mode (verbal/visual), and prior knowledge levels (High, Medium, Low). Dependent variables were student achievement scores on the different criterion tests (drawing, terminology, identification, comprehension, and composite).

Analysis of variance procedures were conducted on criterion test scores achieved by students in each of the prior knowledge levels for each of the eight cells. Data from the drawing test, for which there was only one test format, were analyzed separately. Alpha was set as the .05 level for each analysis of variance. Where significant F-ratios were found to exist, Tukey's Wholly Significant Different (WSD) procedure for comparison between two or more means was utilized. In those situations in which the Bartlett test for homogeneity of variance revealed heterogenous variances

on a specific dependent measure, the heterogeneous variance option of the Tukey WSD procedure was utilized for the comparisons between means. When the heterogeneous variance option is selected, the individual variances of the subgroups being tested are averaged and used for the standard error, whereas for homogeneous variances, the standard error is the mean square within, which is the average variance of all groups involved in the particular dependent measure. This option is an application of the Behrens-Fisher statistic, t', and results in a more conservative critical value by computation of the degrees of freedom (df) using the data (that is, the n's, means, and variances). Howell and Games (1974) have shown that use of the Behrens-Fisher t' with heterogeneous variances results in control of both per comparison probability of Type I error and the family-wise probability of Type I error (FWI).

## Results

The analysis of variance conducted on the pretest scores indicated that significant differences existed between students in each of the levels in the eight treatments. (See Tables 1 and 2.) Consequently, all further analyses were within treatments.

Table 1 presents the means and variances achieved by students on the criterion measures. Table 2 illustrates the results of one-way analysis on the scores achieved by students in the three prior knowledge levels (H, M, L) on each criterion test for the different treatments. Blank areas in Table 2 indicate where significant differences in achievement did not exist among students (H,M, L) on the different criterion tests. Table 3 presents the results of Tukey's WSD follow-up analysis, indicating which of the prior knowledge levels profited most from the various instructional treatments. In three instances (Drawing Test, Treatments 5 and 8; Identification Test, Treatment 1) where significant differences were found to exist (see Table 2), insignificant differences were found among the students when mean-wise comparisons were conducted on the achievement scores (see Table 3) of students in the high, medium, and low prior knowledge levels. Table 4 also illustrates the results of the mean-wise comparisons and identifies where significant differences occurred in achievement among students possessing different degrees of prior knowledge (high, medium, low) in the five criterion measures. The blank areas on Table 4 indicate where significant differences in achievement did not occur.

## Discussion and Interpretation

The purpose of this study was to examine the instructional impact that different types of practice activities used to complement visualized instruction had on the achievement of students possessing different levels of prior knowledge (H, M, L). Additionally, the effectiveness of verbal and visual test formats and covert and overt practice activities was examined.

Students possessing the high prior knowledge level consistently achieved equivalent or significantly higher scores on the criterion measures than did students with low and medium prior knowledge levels, regardless of

the type of practice or evaluation strategy employed (see Table 4). Additionally, the results indicated that identical practice strategies are not equally effective in facilitating the achievement of students possessing different levels of prior knowledge. Table 4 also indicates that as the complexity of the practice strategy increased (moved from covert to overt) greater positive impact was made in student performance. This increased overtness also offers to be an effective instructional technique for reducing differences in achievement between students with low and medium levels of prior knowledge on the criterion measures (Levels 3 and 4 of Factor A, Table 4). Also, it should be noticed that when students received the visual test format for Level 3 and 4 of Factor A (Treatments 6 and 8) differences which existed on the verbal test treatments (Treatments 5 and 7) disappeared.

As the practice strategies increased in complexity, their instructional effectiveness improved on each instructional objective--in terms of reducing differences among students (H, M, L). This would support the contentions of other researchers that different levels of information processing (practice) result in different degrees of information acquisition (Anderson, 1970; Craik and Lockhart, 1972; Craik & Tulving, 1975). Andre and Womack (1978) and Friedman & Richards (1981) have also reported research which supports the notion that the more deeply the material is processed the more completely it is learned. Andre (1979) has indicated that information processing can be considered to exist along a continuum extending from the superficial processing of perceptual features to intense processing for the meaning of the information.

In examining the general retrieval effects of verbal-visual test formats (Table 4, Treatments 5 & 6; 7 & 8) it appears that the visual tests were most efficient in reducing achievement differences--or in providing the appropriate evaluation environment necessary--for students in the three prior knowledge levels to retrieve acquired information. Although no comparisons to determine the relative effectiveness of treatments 5 & 6 and 7 & 8 were conducted, a visual inspection of the means (Table 1) reveals that, in general, student performance on the visual criterion tests was higher than that achieved by students receiving the verbal tests on all criterion measures for students in the three prior knowledge levels. The higher scores on the visual test may be explained by the encoding specificity principle (Battig, 1979; Nitsch, 1977; Tulving, 1979). Since the visual test situation in this study closely matched the instruction received in the initial learning situation, the visuals employed in the tests provided critical cues needed by students to retrieve the encoded information (Bransford, 1979).

## Summary

The results of literature reviewed for this study indicated that students' prior knowledge level, practice strategies, and test formats were important instructional variables. This study was designed to examine how different information processing (practice) strategies influence achievement of different educational objectives by students at different levels of prior knowledge when students are evaluated in the verbal and visual test mode.

A number of summary generalizations may be derived from the results obtained in this study:

(a) Practice strategies can be effective instructional variables in facilitating student achievement from visualized instruction;

(b) Practice strategies can be effective instructional variables in reducing differences in achievement among students possessing different prior knowledge entry levels (H, M, L);

(c) Different practice strategies appear to have differential effects in promoting student achievement of different educational objectives;

(d) Verbal and visual tests do not appear to be equally effective in assessing information communicated by visualized instruction--for all types of educational objectives.

Recommendations for Further Research

Since the analysis of variance which was conducted on the pretest scores achieved by the student in the high, medium and low prior knowledge levels in the eight treatments yielded a significant F-ratio, examination of the relative effectiveness of the individual treatments (practice activities) and comparisons between the verbal/visual test formats was precluded. Consequently, all analyses conducted were in-treatment analyses which focused on the effect each treatment had on student performance where students were identified as being in the high, medium and low prior knowledge levels. Further research is needed where the pretest is administered and scored separately so that students might be randomly assigned not only to individual treatments but also to the high, medium and low knowledge levels. This procedure would enable the investigator to examine more precisely the relative instructional effects of the individual practice activities and also the relative effectiveness of the verbal and visual test formats.

Also, the utilization of additional treatments incorporating practice activities commonly used in instructional strategies would increase the fruitfulness and the generalizability of the results obtained in this study. Additionally, if delayed testing time, four and six weeks after the initial testing sequence were implemented, a more valid assessment would be obtained as to the retrieval potential of the verbal and visual tests over time.

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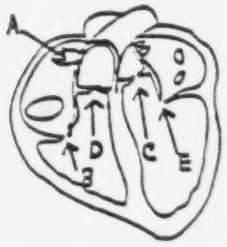
Plate 1. Sample questions from the identification test

aortic valve




left auricle

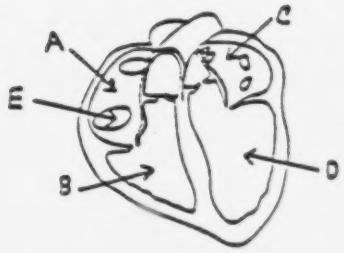
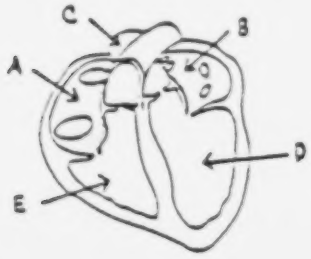



Plate 2. Sample questions from the terminology test

The chamber of the heart which pumps oxygenated blood to all parts of the body:




The part(s) of the heart which control(s) its contraction and relaxation:

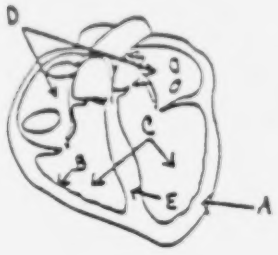



Plate 3. Sample question from the comprehension test

The parts of the heart through which blood is being forced during the second contraction of the systolic phase:

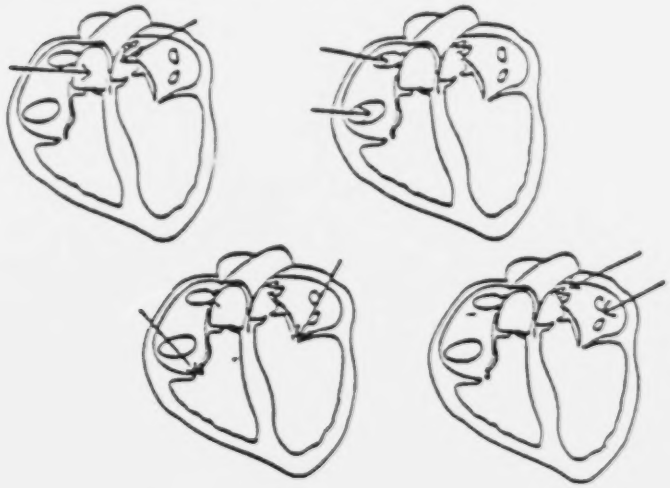
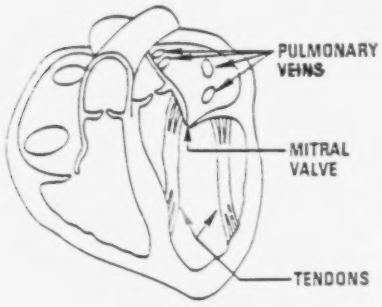


Figure 1. Sample questions from the tests in the VISUAL FORMAT

FIGURE 2: SAMPLES OF THE PRACTICE STRATEGIES (Levels of Factor A).

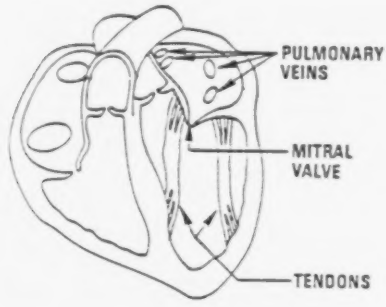
PLATE 1: VISUALIZED INSTRUCTION




Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavas, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

PLATE 2: VISUALIZED INSTRUCTION PLUS COVERT VERBAL PRACTICE: READING SUMMARIES




Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavas, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

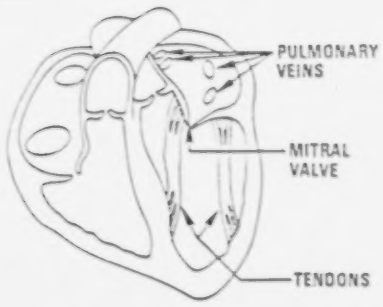
The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

(10) As the blood returns to the heart from the lungs, it enters the heart through pulmonary veins and is deposited in the left auricle.

(11) The mitral valve is located between the left auricle and the left ventricle.

PLATE 3: VISUALIZED INSTRUCTION PLUS OVERT VERBAL PRACTICE: FILL-IN QUESTIONS

[3]. right
[4]. pulmonary



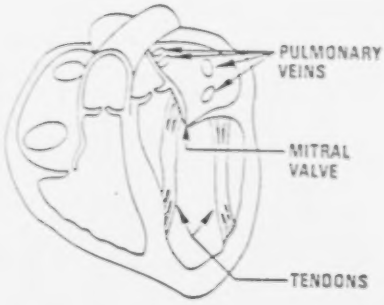

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavas, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

(9) As the blood returns to the heart from the lungs, it enters the heart through [15]_____ veins and is deposited in the [16]_____ auricle.

(9) The [17]_____ valve is located between the left auricle and the left ventricle.

PLATE 4: VISUALIZED INSTRUCTION PLUS OVERT VISUAL PRACTICE: SHADING OR PICTURES




Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavas, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

(15) Color the pulmonary veins black.

(16) Color the left auricle green.

(17) Color the mitral valve yellow.



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Table 1. Means and Variances for Each Treatment Group on the Pretest Scores and On Each Criterion Measure

| | LEVEL 1 OF FACTOR A | | | | LEVEL 2 OF FACTOR A | | | | LEVEL 3 OF FACTOR A | | | | LEVEL 4 OF FACTOR A | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TREATMENT 1 Verbal Test | | TREATMENT 2 Visual Test | | TREATMENT 3 Verbal Test | | TREATMENT 4 Visual Test | | TREATMENT 5 Verbal Test | | TREATMENT 6 Visual Test | | TREATMENT 7 Verbal Test | | TREATMENT 8 Visual Test | |
| A. Pretest Analysis | | | | | | | | | | | | | | | | |
| H | 28.00 | 3.11 | 28.60 | 1.60 | 29.00 | 1.33 | 27.40 | 5.60 | 26.00 | 1.04 | 29.20 | 2.13 | 28.40 | 1.15 | 28.80 | 2.31 |
| M | 21.00 | .89 | 23.40 | 1.60 | 24.20 | 1.96 | 23.20 | .62 | 22.80 | 1.04 | 23.60 | 2.13 | 23.80 | .62 | 22.40 | 2.31 |
| L | 18.00 | 5.78 | 20.40 | 1.60 | 19.00 | 8.89 | 19.20 | 8.62 | 19.40 | 1.04 | 19.80 | 2.13 | 18.60 | 5.60 | 18.40 | 2.31 |
| B. Drawing Test | | | | | | | | | | | | | | | | |
| H | 13.20 | 33.73 | 16.10 | 5.47 | 16.50 | 3.61 | 16.30 | 9.43 | 11.10 | 13.18 | 17.50 | 1.67 | 15.40 | 23.60 | 19.20 | .62 |
| M | 13.90 | 14.32 | 17.50 | 5.47 | 15.00 | 10.44 | 14.00 | 9.43 | 14.70 | 13.18 | 17.10 | 3.88 | 14.50 | 21.61 | 16.80 | 9.73 |
| L | 18.20 | 3.29 | 14.60 | 5.47 | 11.90 | 36.99 | 11.60 | 9.43 | 14.90 | 13.18 | 15.10 | 14.99 | 17.90 | 3.43 | 18.80 | .84 |
| C. Identification Test | | | | | | | | | | | | | | | | |
| H | 17.60 | 1.60 | 16.60 | 3.60 | 18.00 | 1.78 | 17.20 | 5.86 | 17.60 | 7.37 | 16.30 | 4.90 | 19.20 | .84 | 19.00 | .44 |
| M | 14.70 | 22.23 | 16.20 | 1.51 | 13.00 | 20.67 | 14.30 | 5.86 | 14.50 | 11.17 | 15.80 | 7.73 | 17.20 | 5.51 | 18.80 | 1.95 |
| L | 18.00 | 3.56 | 12.20 | 9.73 | 11.90 | 16.10 | 12.40 | 5.86 | 14.60 | 14.71 | 17.30 | 5.43 | 14.40 | 19.16 | 19.10 | 2.10 |
| D. Terminology Test | | | | | | | | | | | | | | | | |
| H | 17.50 | 6.49 | 14.20 | 6.77 | 17.20 | 3.29 | 13.30 | 13.57 | 16.60 | 11.39 | 14.80 | 5.29 | 17.10 | 8.23 | 18.60 | 1.77 |
| M | 12.50 | 6.49 | 14.60 | 6.77 | 11.70 | 22.90 | 11.70 | 9.57 | 13.20 | 11.39 | 13.80 | 5.07 | 15.80 | 8.23 | 17.10 | 1.77 |
| L | 13.30 | 6.49 | 11.10 | 6.77 | 11.30 | 12.01 | 11.60 | 2.49 | 12.80 | 11.39 | 14.50 | 11.17 | 13.80 | 8.23 | 17.40 | 1.77 |
| E. Comprehension | | | | | | | | | | | | | | | | |
| H | 15.10 | 7.66 | 14.30 | 5.64 | 14.70 | 16.41 | 13.50 | 19.83 | 14.90 | 9.40 | 13.00 | 3.11 | 16.00 | 9.24 | 18.80 | .84 |
| M | 11.20 | 11.07 | 11.30 | 5.64 | 9.10 | 16.41 | 12.40 | 6.49 | 13.00 | 9.40 | 13.40 | 6.04 | 13.90 | 9.24 | 17.90 | 2.77 |
| L | 11.50 | .72 | 8.00 | 5.64 | 8.00 | 16.41 | 11.00 | 3.11 | 10.10 | 9.40 | 13.00 | 22.67 | 12.50 | 9.24 | 17.90 | 2.32 |
| Total Test | | | | | | | | | | | | | | | | |
| H | 50.00 | 16.44 | 45.00 | 24.61 | 49.90 | 24.77 | 44.00 | 44.98 | 49.10 | 75.31 | 44.10 | 18.77 | 52.30 | 13.12 | 56.60 | 4.71 |
| M | 39.80 | 95.73 | 43.60 | 24.61 | 33.80 | 183.73 | 38.40 | 44.98 | 40.70 | 75.31 | 43.00 | 20.44 | 46.90 | 50.99 | 50.80 | 88.17 |
| L | 43.00 | 16.22 | 31.30 | 24.61 | 31.20 | 114.84 | 35.00 | 44.98 | 37.50 | 75.31 | 44.80 | 96.40 | 40.60 | 122.49 | 54.00 | 11.77 |

**Table 2.** Analyses of Variance of Students' Achievement Scores for Each Treatment Group on Each Criterion Measure.

| TREATMENTS / CRITERION TEST | LEVEL 1 OF FACTOR A | | LEVEL 2 OF FACTOR A | | LEVEL 3 OF FACTOR A | | LEVEL 4 OF FACTOR A | |
|---|---|---|---|---|---|---|---|---|
| | Treatment 1 Verbal Test | Treatment 2 Visual Test | Treatment 3 Verbal Test | Treatment 4 Visual Test | Treatment 5 Verbal Test | Treatment 6 Visual Test | Treatment 7 Verbal Test | Treatment 8 Visual Test |
| Physiology Pretest | F=80.80, df=2, p<.05 | F=107.58, df=2, p<.05 | F=61.62, df=2, p<.05 | F=33.98, df=2, p<.05 | F=105.04, df=2, p<.05 | F=104.81, df=2, p<.05 | F=97.75, df=2, p<.05 | F=119.08, df=2, p<.05 |
| Drawing | F=4.28, df=2, p<.05 | F=3.84, df=2, p<.05 | | F=5.86, df=2 p<.05 | F=3.47, df=2 p<.05 | | | F=4.43, df=2, p<.05 |
| Identification | F=3.55, df=2, p<.05 | F=11.96, df=2, p<.05 | F=8.23, df=2, p<.05 | F=9.98, df=2 p<.05 | | | F=6.84, df=2, p<.05 | |
| Terminology | F=11.12, df=2, p<.05 | F=5.42, df=2, p<.05 | F=8.54, df=2, p<.05 | | F=3.83, df=2, p<.05 | | F=3.56, df=2, p<.05 | F=3.57, df=2, p<.05 |
| Comprehension | F=7.27, df=2, p<.05 | F=17.62, df=2, p<.05 | F=7.87, df=2, p<.05 | | F=6.22, df=2, p<.05 | | F=3.36, df=2, p<.05 | F=1.37, df=2, p<.05 |
| Total Test | F=6.36, df=2, p<.05 | F=23.09, df=2, p<.05 | F=9.52, df=2, p<.05 | F=4.59, df=2, p<.05 | F=4.77, df=2, p<.05 | | F=5.51, df=2, p<.05 | F=2.42, df=2, p<.05 |

Table 3. Tukey's Follow-up Analyses on Students' Performance for Each Treatment Group on Each Criterion Measure

| TREATMENTS / CRITERION TEST | LEVEL 1 OF FACTOR A | | | | | | LEVEL 2 OF FACTOR A | | | | | | LEVEL 3 OF FACTOR A | | | | | | LEVEL 4 OF FACTOR A | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TREATMENT 1 Verbal Test | | | TREATMENT 2 Visual Test | | | TREATMENT 3 Verbal Test | | | TREATMENT 4 Visual Test | | | TREATMENT 5 Verbal Test | | | TREATMENT 6 Visual Test | | | TREATMENT 7 Verbal Test | | | TREATMENT 8 Visual Test | | |
| | t | df | cv | t | df | cv | t | df | cv | t | df | cv | t | df | cv | t | df | cv | t | df | cv | t | df | cv |
| Physiology Pretest | 1 2 10.60 | 17 | 2.57 | 1>2 14.50 | 27 | 2.48 | 1>3 9.89 | 12 | 2.67 | 1>3 6.88 | 17 | 2.57 | 1>3 14.47 | 27 | 2.48 | 1>3 14.40 | 27 | 2.48 | 1>3 11.93 | 13 | 2.64 | 1>3 15.30 | 27 | 2.48 |
| | 1>3 11.07 | 14 | 2.62 | 1>3 9.19 | 27 | 2.48 | 1>2 8.36 | 17 | 2.57 | 1>2 5.33 | 11 | 2.70 | 1>2 7.01 | 27 | 2.48 | 1>2 8.58 | 27 | 2.48 | 1>2 10.93 | 17 | 2.57 | 1>2 9.42 | 27 | 2.48 |
| | 2>3 3.67 | 12 | 2.67 | 2>3 5.30 | 27 | 2.48 | 2>3 4.99 | 13 | 2.69 | 2>3 4.16 | 10 | 2.74 | 2>3 7.46 | 27 | 2.48 | 2>3 5.82 | 27 | 2.48 | 2>3 6.59 | 11 | 2.70 | 2>3 5.89 | 27 | 2.48 |
| Grading | 1>2 .31 | 15 | 2.60 | 1>2 1.34 | 27 | 2.48 | | | | | | | | | | | | | | | | 1>3 1.05 | 18 | 2.55 |
| | 1>3 2.59 | 11 | 2.70 | 1>3 1.43 | 27 | 2.48 | | | | 1>3 3.42 | 27 | 2.48 | 1>3 2.34 | 27 | 2.48 | | | | | | | 1>2 2.36 | 10 | 2.74 |
| | 3>2 3.24 | 13 | 2.64 | 2>3 2.77 | 27 | 2.48 | | | | 1>2 1.68 | 27 | 2.48 | 1>2 .12 | 27 | 2.48 | | | | | | | 2>3 1.94 | 11 | 2.70 |
| | | | | | | | | | | 2>3 1.75 | 27 | 2.48 | 2>3 2.21 | 27 | 2.48 | | | | | | | | | |
| Identification | 1>2 1.88 | 10 | 2.74 | 1>3 3.81 | 15 | 2.60 | 1>3 4.56 | 11 | 2.70 | 1>3 4.43 | 27 | 2.48 | | | | | | | | | | | | |
| | 1>3 .56 | 16 | 2.58 | 1>2 .56 | 15 | 2.60 | 1>2 3.34 | 11 | 2.70 | 1>2 2.68 | 27 | 2.48 | | | | | | | | | | | | |
| | 1>3 2.05 | 12 | 2.67 | 2>3 3.77 | 12 | 2.67 | 2>3 .54 | 18 | 2.55 | 2>3 1.76 | 27 | 2.48 | | | | | | | | | | | | |
| Terminology | 1 2 4.39 | 27 | 2.48 | 1>3 2.66 | 27 | 2.48 | 1>3 4.77 | 14 | 2.62 | | | | | | | | | | 1>3 3.39 | 10 | 2.74 | | | |
| | 1>3 3 67 | 27 | 2.48 | 1>2 .34 | 27 | 2.48 | 1>2 3.40 | 12 | 2.67 | | | | 1>3 2.52 | 27 | 2.48 | | | | 1>2 2.51 | 12 | 2.67 | | | |
| | 2>3 70 | 27 | 2.48 | 2>3 3.01 | 27 | 2.48 | 2>3 .21 | 16 | 2.58 | | | | 1>2 2.25 | 27 | 2.48 | | | | 2>3 1.78 | 14 | 2.62 | | | |
| | | | | | | | | | | | | | 2>3 .26 | 27 | 2.48 | | | | | | | | | |
| Comprehension | 1 3 3.93 | 11 | 2.70 | 1>3 5.93 | 27 | 2.48 | 1>3 3.70 | 27 | 2.48 | | | | 1>3 3.50 | 27 | 2.48 | | | | 1>3 2.57 | 27 | 2.48 | 1>3 2.01 | 27 | 2.48 |
| | 1>2 2.85 | 17 | 2.57 | 1>2 2.83 | 27 | 2.48 | 1>2 3.09 | 27 | 2.48 | | | | 1>2 1.39 | 27 | 2.48 | | | | 1>2 1.01 | 27 | 2.48 | 1>2 2.52 | 27 | 2.48 |
| | 2>3 .28 | 10 | 2.74 | 2>3 3.11 | 27 | 2.48 | 2>3 .61 | 27 | 2.48 | | | | 2>3 2.12 | 27 | 2.48 | | | | 2>3 1.55 | 27 | 2.48 | 2>3 .50 | 27 | 2.48 |
| Total Test | 1>3 3.87 | 18 | 2.55 | 1>3 6.18 | 27 | 2.48 | 1>3 5.01 | 13 | 2.64 | 1>3 5.00 | 27 | 2.48 | 1>3 2.99 | 27 | 2.48 | | | | 1>3 2.58 | 27 | 2.48 | | | |
| | 1>2 3.05 | 12 | 2.67 | 1>2 .63 | 27 | 2.48 | 1>2 3.53 | 11 | 2.70 | 1>2 1.87 | 27 | 2.48 | 1>2 2.16 | 27 | 2.48 | | | | 1>2 1.54 | 27 | 2.48 | | | |
| | 2>3 .96 | 12 | 2.67 | 2>3 5.54 | 27 | 2.48 | 2>3 .48 | 17 | 2.57 | 2>3 1.13 | 27 | 2.48 | 2>3 .83 | 27 | 2.48 | | | | 2>3 1.03 | 27 | 2.48 | | | |
| | | | | | | | | | | | | | | | | | | | 1>3 3.18 | 11 | 2.70 | | | |
| | | | | | | | | | | | | | | | | | | | 1>2 2.13 | 13 | 2.64 | | | |
| | | | | | | | | | | | | | | | | | | | 2>3 1.51 | 15 | 2.60 | | | |

cv = Critical value
1 = High prior knowledge
2 = Medium prior knowledge
3 = Low prior knowledge

Table 4. Treatments Most Effective in Facilitating Student Achievement on Each Criterion Measure

| CRITERION TESTS | Level 1 of Factor A | | Level 2 of Factor A | | Level 3 of Factor A | | Level 4 of Factor A | |
|---|---|---|---|---|---|---|---|---|
| | Treatment 1 Verbal Test | Treatment 2 Visual Test | Treatment 3 Verbal Test | Treatment 4 Visual Test | Treatment 5 Verbal Test | Treatment 6 Visual Test | Treatment 7 Verbal Test | Treatment 8 Visual Test |
| A. Pretest Analysis | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3<br>2 > 3 |
| B. Drawing Test | 3 > 2 | 2 > 3 | | 1 > 3 | | | | |
| C. Identification Test | | 1 > 3<br>2 > 3 | 1 > 2<br>1 > 3 | 1 > 2<br>1 > 3 | | | 1 > 3 | |
| D. Terminology Test | 1 > 2<br>1 > 3 | 1 > 3<br>2 > 3 | 1 > 2<br>1 > 3 | | 1 > 3 | | 1 > 3 | 1 > 2 |
| E. Comprehension Test | 1 > 2<br>1 > 3 | 1 > 2<br>1 > 3<br>2 > 3 | 1 > 2<br>1 > 3 | | 1 > 3 | | 1 > 3 | |
| Total Test | 1 > 2<br>1 > 3 | 1 > 3 | 1 > 2<br>1 > 3 | 1 > 3 | 1 > 3 | | 1 > 3 | |

1 = High entering behavior
2 = Medium entering behavior
3 = Low entering behavior